MONDAY, JANUARY 10, 1859.

JAMES HENTHORN TODD, D. D., President, in the Chair.

His Grace the Duke of Manchester, Alphonse Gages, Esq., and James Graham Hildige, Esq., were elected Members of the Academy.

MICHAEL DONOVAN, M. R. D. S., Hon. Member of the Philadelphia College of Pharmacy, &c., read the following paper:—

DESCRIPTION OF A HORIZONTAL SUNDIAL, WHICH, WHEN REMOVED FROM ONE SITUATION TO ANOTHER, RESUMES THE POSITION NECESSARY FOR INDICATING SOLAR TIME; AFFORDS MEANS OF READING ITS INDICATIONS WITH PRECISION; EFFACES PENUMBRA, AND REMEDIES CERTAIN LOCAL CAUSES OF IRREGULARITY.

A SUNDIAL possessing the properties indicated by the title of this communication renders a little more complication necessary than has been hitherto resorted to in the construction of those generally simple instruments. The complication is to no great amount; and, when the advantages are considered, it will perhaps appear that it was not introduced in vain. If accurately made, the instrument will do its duty with great exactness, will obviate certain local sources of error incidental to all movable dials, and with less trouble in the management than the description of the mode of using it might lead a person to suppose. Most of the advantages of the dial are peculiar to itself, the means of obtaining them never having been applied to any other, although contributing much to its convenience, utility, and adequacy. The following brief account will sufficiently explain the construction:—

The principle of the mariner's compass affords the obvious means of obtaining the horizontal and meridional position of the dial. The dial-plate, of sufficient area to afford an open graduation, must be made of a very light, yet refractory material: such a substance is talc, a mineral unalterable under any circumstances of heat or moisture, even when as thin as paper. A circular very thin lamina of this mineral, about six inches in diameter, is to be covered on both surfaces with the thinnest white paper, on one of which the usual hour-lines with their subdivisions are to be drawn. This plate is to be mounted on a bar-magnet as a diameter, about the thickness of a silver threepence, and about and half an inch in breadth, and in length a quarter of an inch longer than the diameter of the plate: its ends, therefore, project one-eighth of an inch beyond the circumference. A mark on the south end projection acts as the index to a graduated arc of 30 degrees, drawn on a part of the circumference at the vacant south-east of the dial-plate. This is the declination arc. The index is made to correspond with such degree of the arc as represents the angle of magnetic declination of that period. According as the magnetic declination of any period is known to have varied, a corresponding variation must be made in the angle, by turning the dial-plate on the common axis of itself and the magnetic bar, until the index and

the proper degree of the declination arc correspond. The change of declination will cause a change of time on the dial of about eighteen seconds each year at noon. The declination at present is, I believe, 25° 41′ west.

The style is a human hair, which, passing up through a hole in the centre, whence the hour-lines are drawn, forms with the plate an angle equal to the latitude of the place, and is sustained at that elevation by a light arch of brass fixed to a thin brass bar which passes diametrically under the dial-plate, in the direction of its meridian line, to give steadiness to the whole. Adequate tension of the hair, a hygrometric substance, is secured by a small weight underneath, or by a weak spring. The perfect horizontality of the dial-plate is attained by bits of paper pasted to the under surface where required. The total weight of all the parts just described should not exceed one ounce; so that the dial will be under the control of the magnetic bar, and will return, when disturbed, to its right position with the greatest accuracy—a condition without which the instrument were of little use. The steel pivot on which the dial turns is fixed to the dial-plate itself, and is supported on an agate hollowed just sufficiently to prevent its falling off. I find that the point of a fine sewing-needle answers best as a pivot, and with this advantage, that it may be so adapted as easily to permit replacement by a new one as often as required.

To secure the dial against movements of the air, it is necessary that it be covered with a hemisphere of glass resting on the stand of the instrument, in the manner of a French shade. The hemisphere, however necessary in this respect, produces an effect which, unless obviated, would render the dial useless: when placed in sunshine, a caustic of reflection illuminates the exact spot of the dial-plate where the shadow of the hair-style ought to fall; hence there could be no shadow. The obvious remedy is to paint the reflecting portion of the interior of the hemisphere with dull black paint.

A lifter constantly sustains the weight of the dial, unless when it is in use, to prevent the effects of friction on the very sharp steel point. The whole instrument is mounted on a pillar, for reasons which will hereafter appear.

When the radius of the dial is about five inches, the shadow of the hair-style, although weak, will reach the graduation in all parts, spread out by penumbra, it is true, towards its termination amongst the noontide long hour-lines; but still, if its centre be observed, adequate to indicate the time with sufficient distinctness for ordinary purposes. If greater accuracy be required, as for setting clocks and watches, where standard time-keepers are not accessible, the following mode of observation will be found sufficient; and herein is one of the peculiar advantages of this construction:—Let the observer place himself in such a situation that, one eye being closed, he can with the other see both the hair-style and the strongest and narrowest part of the shadow united into one line. At that moment, let him glance his eye along the hair-style to the graduation, where the hair will appear upon one or other of

the divisions of the hour-circle, or between two of them; and in this way the time can be easily estimated to half a minute, supposing the hours to be subdivided into spaces equal to three minutes each.

But there may be situations of the sun, or of the dial, or of the observer, or there may be peculiarities of his vision, which would render the ascertainment of the hour by the foregoing method impracticable. In such cases a new method becomes necessary, to attain precision, the object of which is practically to efface the penumbra, the great enemy to all gnomonic observations.

After unsuccessfully trying a number of experiments, I found that, by the employment of the following appendage, definiteness may be given to the spread and weak part of the shadow, and the penumbra reduced to an imperceptible size. It consists of a hoop of brass about two inches in diameter, and three-quarters of an inch in depth, soldered at one end to a circular plate of brass of the same diameter, a sufficiency of the centre of which has been cut out for the insertion of a double concave lens about an inch and a quarter in diameter. The lens should be of about four inches imaginary focus, and of equal concavity on both sides; its precise centre should be found, and permanently marked, by a method well known to opticians. On this centre a very small dot is to be made by applying to it the section of a common pin dipped in strong Indian ink. A handle completes the instrument.

To use this, it is to be placed with its open end opposite the sun, so that the whole bottom shall be illuminated, and that no part of the hoop shall cast its shadow within; for then the axis of the lens will fairly be pointed towards the sun. If the lens be held in this position over the hair-style at such a distance (within an inch or two) as gives the thinnest shadow of the hair, a very large, somewhat dark, oval will appear on the dial-plate, surrounded by a broad luminous border. The shadow of the hair-style will now appear broken into two parts near the middle of its length; the parts diverge from each other, one being in the luminous border, the other in the dark oval. The shadow of the Indian ink dot will appear somewhere in the dark portion as a small oval spot, very weak, and surrounded by penumbra. If the lens be moved to the right or left, as the case may require, the two dislocated parts of the shadow of the hair-style will approach each other, and join end to end, forming one straight black line, which must be made to bisect the shadow caused by the dot of Indian ink. This bisection can be done by estimation with very great accuracy, provided the sunlight be sufficiently strong. The straight black line, thus generated by the reunion of its parts, is now destitute of any perceptible penumbra; is longer and stronger than before, and definite. It is capable of reaching and even passing the most distant figures on the dial-plate, and is so narrow that by means of it the observer may estimate half minutes with correctness; whereas, in its natural state it would fill up a space equal to three minutes.

The use of the Indian ink dot on the lens is this: although by moving the lens one way or the other, the broken ends of the two shadows may be united as already described, they may not truly coincide, yet the eye may not be adequate to detect a minute want of coincidence; but

exact coincidence is insured by bisection of the shadow of the black dot; and if that shadow be made to fall very near the graduation, the hour will be precisely and distinctly indicated. The whole operation, which has taken so long to describe, may be performed in three or four seconds.

I found that a large double convex lens also answered for this purpose admirably, with the exception that, as it required to be held at a great distance from the dial, it was very inconvenient.

As movable sundials are intended chiefly for occasional service, and in cities and towns are best adapted for use in the house, attention is required in the selection of a proper situation. The magnetic bar, it is true, will determine the meridional position of the dial; but that position is liable to be disturbed by the numerous appendages belonging to a house, such as massive fire-grates, window-bars, balconies, locks, hinges, and even nails. The dial is naturally brought to the source of light, the open window; and indeed there is seldom any other situation where it can conveniently be exposed to full sunshine. There, however, independently of the before-mentioned causes of derangement, an unsuspected one lurks unseen, which exerts a more detrimental influence than all the others together. On each side of the window are the sash-weights, which, beside their passive reaction on the magnetic bar of the dial, are generally magnetic in their own nature. When the lower sash is raised, its two weights are lowered, and brought within the influence of the magnetic bar; and, in consequence of their inequality of attractive power, it is difficult to find an intermediate spot where they neutralize each other. Besides, the sun may not be then shining in the intermediate spot. For this, and other reasons assigned, it is necessary that the dial should be furnished with means of obviating the disturbing influences which may cause the instrument to show erroneous time, as I have found it to do even to the amount of half an hour, under some circumstances. The remedy is to be found in the following appendages:—

Erected on the stand of the dial is a brass pin, tapered off to a fine point, which, being bent at right angles over the declination arc, and very close to it, indicates how many degrees (if any) the dial-plate is out of its proper position for showing the hour. This pin may be distinguished by the name of the Indicator.

A brass bar, fixed to the stand of the dial, and projecting beyond its circumference, supports a very small ball of soft iron by an arrangement which permits it to be approached towards the magnetic bar on either side, or removed from it, as the case may require; or it may be turned away entirely.

An arm of wood, consisting of three thin narrow slips, so jointed that they can be folded in when not in use, or drawn out and tightened, is movable round the centre underneath the stand. When drawn out, the position of the bar is horizontal; at its end is a light card-paper box, in which a graduated circle is drawn. This circle is traversed by a compass-needle sustained on a steel point. By the length of the arm, which is two feet, the compass-needle, a very small and light one, is removed out of the influence of the magnetic bar, as well as of the mass of iron from which disturbance was apprehended.

The appendages now described come into operation, when it is found that the dial shows incorrect time, notwithstanding that all its parts are in proper relation and condition; for it is then certain that the proximity of iron is the cause. Let the dial be brought to some unquestionable situation in the room or elsewhere: it will take its just position. Draw the folding arms fully out. Turn the dial in such a manner as will cause the indicator to lie exactly over the index mark on the end of the magnetic bar; both indicator and index mark will then point to the degree on the declination arc which corresponds with the declination of the needle at that period. Note the degree of the graduated circle to which the compass-needle happens at that time to point; or if it do not point to any one exactly, move the arm a little, that it may do so, and tighten the joint.

In this state let the instrument be brought to the place of sunshine, taking great care not to alter the relative position of the parts: it is to be placed in such a position that the compass-needle shall again point exactly to the same degree as it did previously. It will now be found that the dial has turned on its pivot several degrees, more or less, away from the indicator. Advance the iron ball to one side or the other of the magnetic bar, until the latter be attracted to its proper position, which will be when the index mark again coincides with the indicator. The dial will now show solar time correctly, notwithstanding the presence of the mass of iron which caused the disturbance, and will remain in proper position, undeviatingly, while this condition of its parts continues.

Nothing remains to be described except that on the lower part of the glass shade is a table of the equation of time for every day in the year.

The following is a summary of the advantages expected from this kind of sundial, if accurately constructed:—It may be removed from place to place, according to change of sunshine, when it will spontaneously assume its proper position. Its situation, whether temporary or permanent, may be in immediate proximity to the iron fixtures of a house, yet no error of time will result. The very small error occasioned by variation of terrestrial magnetism is easily rectified when its amount is worth while. The reading of the shadow on the graduation is rendered more precise. The penumbra is practically effaced. The error of the common sundial, amounting to two minutes, during the passage of the sun across the meridian, and to one minute before and after that period, does not in this dial occur. Finally, it is obvious that although in point of fact the influence of diurnal magnetic declination is not avoided, its effect on the time indicated is altogether too minute to be appreciable on so small a dial.

In conclusion, it is to be observed that, unless when the hour is required to be known with great accuracy, as for setting clocks, nothing more than simple inspection of the shadow on the dial is necessary.

A catalogue of Donations to the Library received since 9th November last was read, and thanks returned to the several donors.